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Characterization of Vadose Zone Sediment: Borehole 299-E33-46 Near B 110 in the B BX-BY Waste Management Area

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Executive Summary

The overall goal of the of the Tank Farm Vadose Zone Project, led by CH2M HILL Hanford Group, Inc., is to define risks from past and future single-shell tank farm activities. To meet this goal, CH2M HILL Hanford Group, Inc., asked scientists from Pacific Northwest National Laboratory to perform detailed analyses on vadose zone sediment from within the B-BX-BY Waste Management Area. This report is the third in a series of three reports to present the results of these analyses. Specifically, this report contains all the geologic, geochemical, and selected physical characterization data collected on vadose zone sediment recovered from a borehole installed approximately 4.5 m (15 ft) northeast of tank B-110 (borehole 299-E33-46).

This report also presents our interpretation of the data in the context of the sediment lithologies, the vertical extent of contamination, the migration potential of the contaminants, and the likely source of the contamination in the vadose zone and groundwater east of the B Tank Farm. The information presented in this report supports the B-BX-BY field investigation report prepared by CH2M HILL Hanford Group, Inc.^(a)

Overall, our analyses identified common ion exchange and heterogeneous (solid phase-liquid solute) precipitation reactions as two mechanisms that influence the distribution of contaminants within that portion of the vadose zone affected by tank liquor. We did not observe significant indications of caustic alteration of the sediment mineralogy or porosity, but we did observe slightly elevated pH values between the depths of 15 and 25 m (52 and 83 ft) bgs. X-ray diffraction measurements indicate no evidence of mineral alteration or precipitation resulting from the interaction of the tank liquor with the sediment. However, no scans of samples by scanning electron microscopy were performed that might suggest that there is faint evidence of caustic attack.

Our analyses do not firmly suggest that the source of the contamination in the groundwater below and to the east of B Tank Farm is the 1971 transfer line leak at B-110. However, we are firmly convinced that the fluids from the transfer line leak event are present in the vadose zone sediments at borehole 299-E33-46 to a depth of 52 m (170 ft) bgs, within the Hanford H2 sand unit. Below this depth the concentration of nitrate still appears to be slightly elevated above natural background levels. There is also elevated technetium-99 between 68 and 69 m (222 and 226 ft) bgs in the Plio-pleistocene mud layer but we can't show that this contamination traveled through the entire vadose zone and in fact may have migrated horizontally from other sources.

The near horizontally bedded, northeasterly dipping sediment likely caused horizontal flow of the migrating contaminants. At borehole 299-E33-46, there are several fine-grained lens within the H2 unit at

(a) *Draft Field Investigation Report for Waste Management Area B-BX-BY*. RPP-10098, Draft, Volume 2, Appendix D, CH2M HILL Hanford Group, Inc., Richland, Washington.

26, 41, and 57 m (85, 168, and 186 ft) bgs that likely cause some horizontally spreading of percolating fluids. The 12.7-ft thick Plio-pleistocene fine-grained silt/clay unit is also an important horizontal flow conduit between 66 to 69.4 m (215 to 227.7 ft) bgs.

The porewater electrical shows a two-lobed elevated plume. The shallower but more concentrated lobe, between 15.42 and 25.91 m (50.6 and 85 ft) bgs, resides within the middle sand sequence in Hanford H2 unit. The shallow lobe appears to pond on top of the fine-grained lens at 85 ft bgs. The slightly less concentrated lobe resides between 27.61 and 42.67 m (90.6 to 140 ft) bgs within the Hanford H2 unit. Thus, the leading edge of the transfer line leak plume appears to reside well above the water table at 78.0 m (255.8 ft) bgs.

Elevated nitrate concentrations in 299-E33-46 borehole sediment start at 50.6 feet bgs but the more concentrated zone resides between 26.8 and 51 m (87.8 and 168 ft) bgs within the Hanford H2 unit. This more concentrated nitrate plume appears to stop at the fine-grained thin lens at 51 m (168 ft) bgs. The peak vadose zone porewater nitrate concentration is 1.5 g/L at 41 m (134 ft) bgs. The deeper units, H3 and PPlz, have porewaters that contain 100 to 200 and 130 mg/L nitrate, respectively. These values appear to be slightly elevated above natural background values. Even the coarse-grained PPlg unit that includes the water table has porewater nitrate concentrations that hover near 50 mg/L suggesting slightly elevated nitrate concentrations penetrate the entire vadose zone at this borehole. However, an alternate source of nitrate within and below the PPlz could be the nearby cribs and trenches with horizontal transport within the very moist fine-grained sediments.

Within the Hanford H2 unit the porewater fluoride and bicarbonate concentrations are also elevated above natural background levels down to a depth of about 37 m (120 ft) bgs. The porewater cation distributions show the ion exchange front wherein the sodium in the tank fluids pushes the naturally occurring divalent cations (calcium, magnesium and strontium) deeper into the sediments and out in front of the plume. The most concentrated portion of the vadose zone plume has a porewater chemical composition that is 0.15M sodium and 0.13 M bicarbonate, 0.01 M fluoride, 0.007 M sulfate, and 0.003 M nitrate. This composition is not as saline as contaminated porewaters below the BX-102 tank or under the S-SX tank farm.

The only detectable radionuclides in the vadose zone sediments from borehole 299-E33-46 are strontium-90, technetium-99 and a faint trace of water leachable uranium, which suggests non-natural uranium at very low concentrations. Strontium-90 is considered to be the primary radionuclide released from tank B-110 transfer line and is concentrated in the sediment between 19 and 28 m (62 and 83 ft) bgs at concentrations between 1,000 and 11,250 pCi/g. Strontium-90 in the sediments is not readily water leachable yielding an insitu desorption K_d value of >100 ml/g. All technetium-99 concentrations in the shallow depths is at or below the detection limit thus it is difficult to determine if the technetium profile at 299-E33-46 can be traced from below the tank all the way to the groundwater. The two more concentrated peaks of technetium-99 are found in the deep H3 unit and in the PPlz unit and it is more likely that the technetium found at the deeper depths is from some horizontal migration of fluids containing technetium-99

from other sources that was carried to depth by active disposal of large quantities of contaminated water or some other driving force such as domestic water line leaks, recharge from topographic lows for snow melt etc.

In summary, the moisture content, pH, electrical conductivity, sodium, and strontium-90 profiles do not suggest that the leading edge of the plume has penetrated below 52 m (170 ft) bgs. The profiles of two mobile constituents, technetium-99 and nitrate, suggest that the leading edge of the plume may have penetrated all the way to groundwater. But there may be other sources of these two mobile contaminants in the deep vadose zone. The very moist PPlz sediments, which contain a perched water table at several nearby wells, is a likely driving force to move fluids from other sources into the borehole environs.

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Acronyms and Abbreviations

ASA	American Society of Agronomy
ASTM	American Society for Testing and Materials
bgs	below ground surface
DFS	Duratek Federal Services, Inc.
EPA	U.S. Environmental Protection Agency
FIR	Field Investigation Report
g's	gravitational forces
GEA	gamma energy analysis
Hf/PPu(?)	Hanford formation/Plio-Pleistocene unit(?)
HPGe	high purity germanium
IC	ion chromatography
ICP	inductively coupled plasma
ICP-MS	inductively coupled plasma mass spectrometer
ICP-OES	inductively coupled plasma – optical emission spectroscopy
ID	inside diameter
NTA	nitrilo triacetic acid
OD	outside diameter
PNNL	Pacific Northwest National Laboratory
PPlc	Plio-Pleistocene calcic
PPlg	Plio-Pleistocene gravelly sand or sandy gravel
PPlz	Plio-Pleistocene mud
RCRA	Resource Conservation and Recovery Act
REDOX	Reduction Oxidation Plant
SEM	scanning electron microscope
TEM	transmission electron microscopy
UFA	unsaturated flow apparatus (ultracentrifuge for squeezing porewater out of sediment)
VZMS	vadose zone monitoring system
vol%	volumetric water content
XRD	x-ray diffraction
XRF	x-ray fluorescene
WMA	Waste Management Area
wt%	gravimetric moisture content

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